NPS-AM-13-C10P01R08-037

EXCERPT FROM THE

PROCEEDINGS

OF THE

TENTH ANNUAL ACQUISITION RESEARCH SYMPOSIUM ACQUISITION MANAGEMENT

Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity

Mary Maureen Brown
University of North Carolina Charlotte

Published April 1, 2013

Report Documentation Page	*Form Approved OMB No. 0704-0188*

1. REPORT DATE **01 APR 2013**	2. REPORT TYPE	3. DATES COVERED **00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE **Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of North Carolina Charlotte, 9201 University City Blvd,Charlotte,NC,28223**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This research examines DoD acquisition from the context of a network of interrelated programs that exchange and share resources for the purpose of establishing joint capabilities. The research focuses on the joint space of major defense acquisition programs (MDAPs): the space where transactions form interdependencies among MDAP programs. The research is especially salient because, to date, little is known about the risks associated with interdependent activities. This paper provides a short description of some of the network characteristics of the funding and data interdependencies of major defense acquisition programs. Where the discussion focused on descriptions, recent advances allow the ability to test the structural descriptions on program performance. In exponential random graph models (ERGM), the ties serve as predictors of performance. ERGMs are capable of testing a host of structural arrangements for their influence on outcomes. Employing Markov Chain Monte Carlo Maximum Likelihood Estimation techniques, probabilities can be ascertained. Over the coming months the structural nature of the interdependencies will be analyzed and evaluated for their influence on acquisition performance.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**24**	

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact any of the staff listed on the Acquisition Research Program website (www.acquisitionresearch.net).

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

Preface & Acknowledgements

Welcome to our Tenth Annual Acquisition Research Symposium! We regret that this year it will be a “paper only” event. The double whammy of sequestration and a continuing resolution, with the attendant restrictions on travel and conferences, created too much uncertainty to properly stage the event. We will miss the dialogue with our acquisition colleagues and the opportunity for all our researchers to present their work. However, we intend to simulate the symposium as best we can, and these *Proceedings* present an opportunity for the papers to be published just as if they had been delivered. In any case, we will have a rich store of papers to draw from for next year’s event scheduled for May 14–15, 2014!

Despite these temporary setbacks, our Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) continues at a normal pace. Since the ARP’s founding in 2003, over 1,200 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 70 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a “broker” to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and encourage your future participation.

Unfortunately, what will be missing this year is the active participation and networking that has been the hallmark of previous symposia. By purposely limiting attendance to 350 people, we encourage just that. This forum remains unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. It provides the opportunity to interact with many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. Despite the fact that we will not be gathered together to reap the above-listed benefits, the ARP will endeavor to stimulate this dialogue through various means throughout the year as we interact with our researchers and DoD officials.

Affordability remains a major focus in the DoD acquisition world and will no doubt get even more attention as the sequestration outcomes unfold. It is a central tenet of the DoD’s Better Buying Power initiatives, which continue to evolve as the DoD finds which of them work and which do not. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you’re a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

- Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)
- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
- Commander, Naval Sea Systems Command
- Program Executive Officer, Integrated Warfare Systems
- Army Contracting Command, U.S. Army Materiel Command
- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Director, Acquisition Career Management, U.S. Army
- Office of Procurement and Assistance Management Headquarters, Department of Energy
- Director, Defense Security Cooperation Agency
- Deputy Assistant Secretary of the Navy, Research, Development, Test, & Evaluation
- Program Executive Officer, Tactical Aircraft
- Director, Office of Small Business Programs, Department of the Navy
- Director, Office of Acquisition Resources and Analysis (ARA)
- Deputy Assistant Secretary of the Navy, Acquisition & Procurement
- Director of Open Architecture, DASN (RDT&E)
- Program Executive Officer, Littoral Combat Ships

James B. Greene Jr. Rear Admiral, U.S. Navy (Ret.)	Keith F. Snider, PhD Associate Professor

Acquisition Management

Naval Ship Maintenance: An Analysis of the Dutch Shipbuilding Industry Using the Knowledge Value Added, Systems Dynamics, and Integrated Risk Management Methodologies

David N. Ford, Thomas J. Housel, and Johnathan C. Mun
Naval Postgraduate School

Time as an Independent Variable: A Tool to Drive Cost Out of and Efficiency Into Major Acquisition Programs

J. David Patterson
National Defense Business Institute, University of Tennessee

The Impact of Globalization on the U.S. Defense Industry

Jacques S. Gansler and William Lucyshyn
University of Maryland

Bottleneck Analysis on the DoD Pre-Milestone B Acquisition Processes

Danielle Worger and Teresa Wu, *Arizona State University*
Eugene Rex Jalao, *Arizona State University and University of the Philippines*
Christopher Auger, Lars Baldus, Brian Yoshimoto, J. Robert Wirthlin, and John Colombi, *The Air Force Institute of Technology*

Software Acquisition Patterns of Failure and How to Recognize Them

Lisa Brownsword, Cecilia Albert, Patrick Place, and David Carney
Carnegie Mellon University

Fewer Mistakes on the First Day: Architectural Strategies and Their Impacts on Acquisition Outcomes

Linda McCabe and Anthony Wicht
Massachusetts Institute of Technology

The Joint Program Dilemma: Analyzing the Pervasive Role That Social Dilemmas Play in Undermining Acquisition Success

Andrew P. Moore, William E. Novak, Julie B. Cohen, Jay D. Marchetti, and Matthew L. Collins
Software Engineering Institute, Carnegie Mellon University

Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity

Mary Maureen Brown
University of North Carolina Charlotte

Leveraging Structural Characteristics of Interdependent Networks to Model Non-Linear Cascading Risks

Anita Raja, Mohammad Rashedul Hasan, and Shalini Rajanna
University of North Carolina at Charlotte
Ansaf Salleb-Aoussi, *Columbia University, Center for Computational Learning Systems*

Lexical Link Analysis Application: Improving Web Service to Acquisition Visibility Portal

Ying Zhao, Shelley Gallup, and Douglas MacKinnon
Naval Postgraduate School

Capturing Creative Program Management Best Practices

Brandon Keller and J. Robert Wirthlin
Air Force Institute of Technology

The RITE Approach to Agile Acquisition

Timothy Boyce, Iva Sherman, and Nicholas Roussel
Space and Naval Warfare Systems Center Pacific

Challenge-Based Acquisition: Stimulating Innovative Solutions Faster and Cheaper by Asking the Right Questions

Richard Weatherly, Virginia Wydler, Matthew D. Way, Scott Anderson, and Michael Arendt
MITRE Corporation

Defense Acquisition and the Case of the Joint Capabilities Technology Demonstration Office: Ad Hoc Problem Solving as a Mechanism for Adaptive Change

Kathryn Aten and John T. Dillard
Naval Postgraduate School

A Comparative Assessment of the Navy's Future Naval Capabilities (FNC) Process and Joint Staff Capability Gap Assessment Process as Related to Pacific Command's (PACOM) Integrated Priority List Submission

Jaime Frittman, Sibel McGee, and John Yuhas, *Analytic Services, Inc.*
Ansaf Salleb-Aoussi, *Columbia University*

Enabling Design for Affordability: An Epoch-Era Analysis Approach

Michael A. Schaffner, Marcus Wu Shihong, Adam M. Ross, and Donna H. Rhodes
Massachusetts Institute of Technology

Measuring Dynamic Knowledge and Performance at the Tactical Edges of Organizations: Assessing Acquisition Workforce Quality

Mark E. Nissen
Naval Postgraduate School

Outcome-Focused Market Intelligence: Extracting Better Value and Effectiveness From Strategic Sourcing

Timothy G. Hawkins, *Naval Postgraduate School*
Michael E. Knipper, *771 Enterprise Sourcing Squadron USAF*
Timothy S. Reed, *Beyond Optimal Strategic Solutions*

Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity

Mary Maureen Brown—Dr. Brown is a professor of public administration at the University of North Carolina–Charlotte, a senior fellow at the Center for Excellence in Municipal Management at George Washington University, and a visiting scientist at the Software Engineering Institute at Carnegie Mellon University. Brown has over 15 years of experience in cross-organizational information systems integration in government. Her research interests center on participatory design, knowledge management, and joint problem solving and program planning. She has extensive experience in the design and development of various technologies for the purposes of reengineering government work processes and facilitating cross-organizational information sharing. Brown received her PhD from the University of Georgia. [marbrown@uncc.edu]

Abstract

This research examines DoD acquisition from the context of a network of interrelated programs that exchange and share resources for the purpose of establishing joint capabilities. The research focuses on the joint space of major defense acquisition programs (MDAPs): the space where transactions form interdependencies among MDAP programs. The research is especially salient because, to date, little is known about the risks associated with interdependent activities. This paper provides a short description of some of the network characteristics of the funding and data interdependencies of major defense acquisition programs. Where the discussion focused on descriptions, recent advances allow the ability to test the structural descriptions on program performance. In exponential random graph models (ERGM), the ties serve as predictors of performance. ERGMs are capable of testing a host of structural arrangements for their influence on outcomes. Employing Markov Chain Monte Carlo Maximum Likelihood Estimation techniques, probabilities can be ascertained. Over the coming months the structural nature of the interdependencies will be analyzed and evaluated for their influence on acquisition performance.

Introduction

In a world of insurgent and asymmetrical warfare, no defense organization is an island. While the Services have engaged in a host of coordinated efforts in the past, the need for situational awareness and rapid response rates demands the synergistic benefits that only wide-scale cross-integration and interoperability affords. Never in the history of the DoD has the rapid fielding of flexible and adaptive technology for countering unconventional and time-sensitive threats been more important.

This research examines DoD acquisition from the context of a network of interrelated programs that exchange and share resources for the purpose of establishing joint capabilities. The research focuses on the joint space of major defense acquisition programs (MDAPs): the space where transactions form interdependencies among MDAP programs. The research is especially salient because, to date, little is known about the risks associated with interdependent activities.

Unfortunately, by and large, the literature on interdependent activities is steeped in contradictory findings. For example, some argue that tight-knit arrangements are more likely to have the social traction needed to overcome environmental difficulties (Sosa, 2011), whereas others argue that loose coupling, or weak ties, may be a better solution (Granovetter, 1973). Some claim that more information is the key to benefit attainment (Comfort, 1994), whereas others claim that more information leads to a false sense of security (Hall, Ariss, & Todorov, 2007). Yet, despite the absence of consistent sage advice,

resource limitations and a demand for comprehensive solutions continue to push organizations toward complex structures for the delivery of products and services.

For this research, jointness, interdependency, exchange, and partnerships all refer to a similar concept: the notion that autonomous organizations build relationships to obtain resources to provide capabilities that, when looked at in totality, form network structures. While it is true that at the individual pair-wise level, these exchanges exist as explicit transactions for the transfer of data, labor, capital, or materials, it is also true that the totality of the various dimensions, coupled with the turbulence of perturbations, influences the cost, schedule, and performance of the acquisition effort.

Organizations in the past sought to limit interdependencies to maintain control over the environment. More recently, however, organizations have sought to leverage the benefits that interdependencies, or partnerships, can provide. Thus, discussions of the nature of structure and how to best organize in the face of increasing needs for holistic comprehensive solutions has taken center stage. The key question seems to be whether organizations can benefit from interdependence while minimizing the negative influences of environmental turbulence. The question, thus, becomes, what structural arrangements and behavioral practices are conducive to achieving the benefits of coordinated actions? The following research explores the nature of the funding and data interdependencies that characterize major defense acquisition programs.

Interdependent Networks

A novice's glance into the field of interdependent organizational-based networks is likely to reveal a terminological jungle of abstract and obscure vocabulary. This section of the report seeks to convey many of the more common network terms and place them in the context of DoD acquisition. Table 1 in the appendix provides a glossary of several of the key terms. At the onset, it is important to recognize that the term *social* is used in a specific empirical context for understanding programmatic interactions: "Social systems of interaction" form the basis from which material equipment and organizational capacities get things done (Turner, 1988).

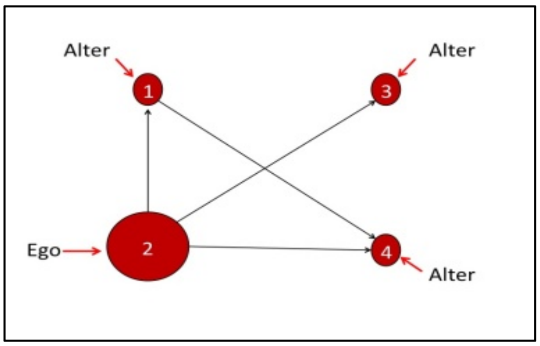
Wasserman and Faust (1994) defined the social network perspective as a focus on the relationships that exist among entities and the patterns and implications of these relationships. Overall, the vantage point is that

- actors and their actions are viewed as interdependent rather than independent, autonomous units;
- relational ties between actors are channels for the transfer of resources; and
- network models view the structural environment as providing opportunities for, or constraints on, individual and collective action (Wasserman & Faust, 1994, pp. 3–4).

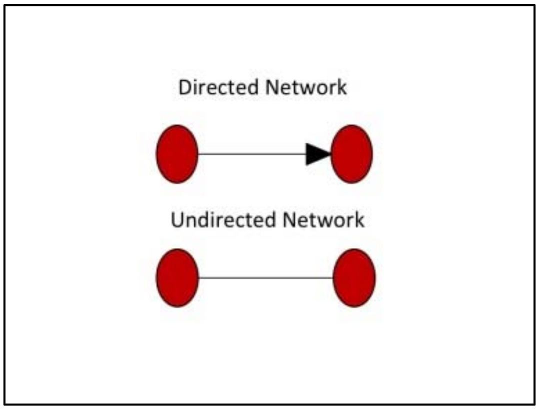
Organizations have long been viewed as resource exchanging agents. When considered in this light, each organization takes input and converts it into outputs that are then provided as inputs to another organization. Nonetheless, in the past, organizations often sought to maintain control over practices and procedures by restricting access to outside influences. Hierarchical organizational models were pursued because they provided stability. But the hierarchical approach was found to be ill-suited to situations in which needs and demands evolved. Hierarchical approaches, due to their inability to adapt, risked the obsolescence that occurred from the inability to adapt to changing needs.

Over the years, researchers have consistently found that demand uncertainty is a key contributor to the choice to forego hierarchical-based approaches in favor of organizational networks. Demand uncertainty arises when organizations lack the ability to predict near-future needs. When organizations are confronted with high levels of demand uncertainty, they require the flexibility to make rapid shifts in their service delivery and production cycles—shifts that a hierarchical approach cannot accommodate. Because networks offer an expanded set of options, they allow the ability to respond to a wider range of contingencies. For example, under asymmetric warfare conditions, the types of solutions that may be required are difficult to predict a priori. Given the uncertainty of the demands of the battle space, warriors require a wide arsenal of alternative and complementary approaches—approaches that must be accessible at a moment's notice. When demand uncertainty is low, organizations often choose more simplistic hierarchical approaches. Under high demand uncertainty, organizations require the ability to leverage a variety of capabilities irrespective of the boundaries of a given organization's purview (Jones, Hesterly, & Borgatti, 1997).

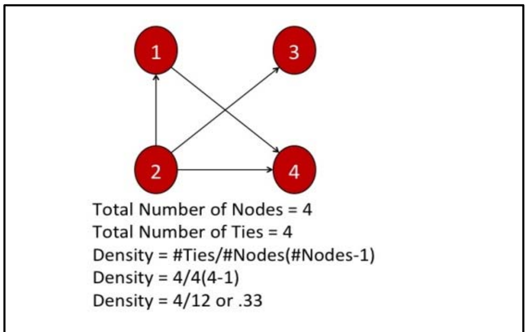
In the work setting, network actors (or nodes) often represent people, teams, or organizations. A tie represents some form of interaction or relationship. In short, network structures provide the "plumbing" for the flow of resources through the network. Interdependent networks are complicated by the fact that they are multidimensional, and as such, understanding their behavior requires consideration of multiple levels of analysis. Typically, networks can be characterized in light of four basic levels: the individual, the subnetwork(s), the entire network, or the multiplex network. A multiplex perspective considers the node from a multi-network consideration. For example, in this report, major defense acquisition program (MDAPs) are examined in light of the performance of the individual program as well as its resulting performance in two different networks: (1) a data-sharing network and (2) a shared budget network. Cross-level effects occur when behaviors at one network level influence behaviors at another network. Cross-level analysis involves looking at behavior across the various networks. The failure to consider cross-level effects may result in misinterpreting the full set of consequences that occur from network behaviors.

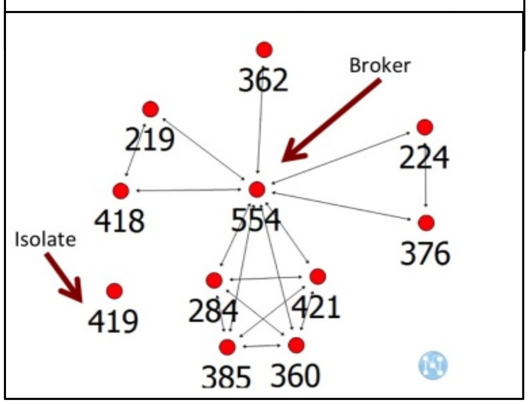


At the individual (or node) level, an ego is the central node of interest, and those connected to the ego are known as alters (see Figure 2 in the appendix). A network rendering from the context of an ego is referred to as an ego-network. A dyad consists of an ego and its adjacent alter. As discussed further in the next section, examining data in light of the dyads (or pairs) provides the ability to test the influence that one node has on another.



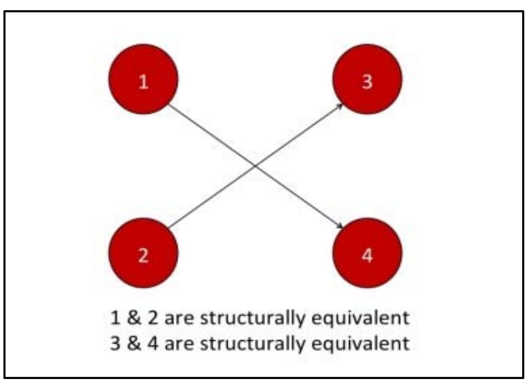
A directed network is one where the flow of resources moves in a specific direction, either inbound to an ego or outbound from an ego (see Figure 3 in the appendix). For example, the data-sharing network identified previously is a directed network because the data flow from one program to another. A directed network can be either sequential or reciprocal in nature. Alternatively, an undirected network is one that is "pooled." In other words, the nodes share a common connection (i.e., a budget), but there is no directional component to the tie. In this case, the tie indicates that the two programs share a common budget.





A node is labeled as a broker when it connects two distinct subnetworks. So in Figure 4 in the appendix, Program Number 554 Multifunctional Information Distribution System Joint Tactical Radio System (MIDS JTRS) acts as a broker between three subnetworks. An isolate is a node with no ties. Again, in Figure 4 in the appendix, Program Number 419 (EA 6B Prowler) is an isolate. In directed networks, a node can serve as a transmitter, a receiver, or a carrier. A bridge is identified when a tie spans two subnetworks. Structural equivalence occurs when two nodes are structurally similar (see Figure 5 in the appendix).

Relying on matrix algebra, a number of metrics have been devised throughout the years to measure networks. Some of the metrics occur at the node or ego level, and others are at the subnetwork or whole-network levels. Nodes are often considered in light of their position, or role, in the network. Many of the ego-level metrics are calculated relative to others in the network.



The degree of a node is the number of ties that a node exhibits. These ties can be measured as inbound or outbound (or both) in a directed network. Another measure is the geodesic distance that one node may be from another. Adjacency identifies direct connections while reachability identifies whether any two nodes are capable of connecting by way of other nodes. Degree centrality identifies the number of ties that a node possesses. The more ties relative to others, the greater the centrality. Closeness, on the other hand, indicates how close a given node is to the remaining nodes. When all of the nodes are close to all of the other nodes, the interaction level among the nodes is typically high.

Network size is often calculated as the sum of the number of nodes or number of ties (see Figure 6 in the appendix). Sometimes networks (or subnetworks) are measured by their longest, or shortest, path. The bridge identified previously is often of interest because it indicates that if the tie between the two nodes can be cut, the network can be disconnected or reduced to its subnetworks. The same holds true for the broker. If a broker is eliminated, the network will be reduced to a number of subnetworks. Node connectivity identifies the minimum number of nodes that have to be removed to disconnect the network. Betweenness is the extent to which a given node lies between other nodes and, thus, could act to facilitate or block the flow of resources.

Density refers to the proportion of ties relative to the absolute total. Relational embeddedness refers to the quality and depth of a single dyadic tie. Structural embeddedness refers to the extent to which a node's alters are connected to each other. Because structural embeddedness reflects the degree of the interactions, it is often used as a proxy for understanding network actions.

In the study of networks, scholars often take either a structural or a connectionist approach. Structural approaches examine the structure of the network and its influence on key variables of interest. Connectionists, on the other hand, focus on the flows between the nodes. Those who study social capital tend to focus on the possibilities of actions that social ties provide. Others, however, tend to be more concerned with diffusion and the dynamics of network change over time. Still, other studies focus on why and how networks develop, how and why they change over time, and finally, what influences they exert. Social capital is mostly studied at the individual level, and diffusion is observed from the perspective of the entire network.

Studies of the influence of dyadic ties on performance have mixed and contradictory findings. For example, Perry-Smith and Shalley (2003) found that weak ties led to creativity, but others claim that strong ties are more advantageous (Sosa, 2011). Others claim that it is not the number of ties but rather the depth of the engagement that matters. No one would be surprised by the idea that relative to fewer ties, more ties may provide organizations with better information that might promote enhanced decision-making. At the same time, information overload and difficulties with scrubbing data to provide information at the proper specification level have become real problems for many managers.

Similarly, studies of embeddedness are equally contradictory. According to some, the more each node knows about the others, the more constraints there are on each other's behaviors. This is often seen as a positive. Parties gather information on whom to avoid as well as potential opportunities and synergies. Structural embeddedness allows the use of sanctions since knowledge of misfeasance influences reputational value. But these constraints can backfire and actually restrict flexibility. Too much embeddedness can also create problems. It can lead to feuding, group think, and welfare support of weak members. Social aspects such as restricting access to exchanges, imposing collective sanctions, and making use of social memory and cultural processes all influence nodal behavior. Apparently, networks and ties matter, but the extent of the influence is highly debatable.

Much of the incongruity in the findings may be due to the difficulties associated with measurement and data collection. Researchers are challenged by the burden of the data collection requirements, and organizations are often frustrated by the extent of the data request. Because multilevel data are needed for each specific relationship, the data collection task can be onerous. Moreover, given that the study of networks is a fairly new phenomenon, typical organizational records often lack insights at a network level. When multilevel data are obtained, an analysis of variance statistical technique termed *hierarchical*

linear modeling or *multilevel modeling* is often employed because it allows the examination of multiple units of analysis simultaneously.

Despite these contradictory findings and data collection difficulties, the examination of networks and ties that manifest as interdependencies is likely to provide substantial insights into a number of issues. First, when considering cost and affordability, examining a program in isolation of the entire value chain is likely to provide erroneous information. Second, a wealth of research illustrates the importance of risk management. Considering the risks of a given program without considering its interdependencies may underestimate the true risk level. Next, in the decision of a start-up or termination, it is essential to know how the inclusion or removal of a program will influence its n-order neighbors. Finally, network conditions may exert powerful influences over program sustainability. The following discussion explores the funding and data networks employed in the acquisition arena.

Interdependency Descriptions

Two sets of interdependencies are examined below. One set reflects funding interdependencies and the other captures data interdependencies. In the organizational arena, interdependencies can be viewed in three ways. As Thompson (1967) illustrates, network arrangements can be pooled, sequential, or reciprocal. Under a pooled arrangement, network actors draw down from a common pool of resources. Under this scenario, the actors do not interrelate, but they are nonetheless interdependent because they all share a common resource that can be depleted. The funding interdependencies described in the next paragraph reflect a pooled relationship. These acquisition programs share a common program element. Thus the interconnections reflect their interdependencies on a common funding source. Sequential relationships are often termed supply chains. In these scenarios resources flow in a sequential manner from program to program. Reciprocal relationships are often seen as the most complex and have the greatest risk. In this case, resources are exchanged and, as a consequence, there is a two-way link among the programs.

Figure 1 in the appendix displays the funding interdependencies over time. As displayed in the figure, the interdependencies have grown increasing complex over time. The density has grown from a low of 6% to a high of 22%. Figure 2 in the appendix reflects the polynomial regression equation and its associated bivariate plot showing growth over the six-year period. Figure 3 in the appendix illustrates the data interdependencies. As demonstrated in the diagram, these interdependencies reflect 326 ties and range from 27% inbound to 16% outbound.

Figures 4 and 5 in the appendix illustrate that both the data and funding interdependencies reflect “preferential attachment.” Preferential attachment was popularized by Barabasi and has gained tremendous attention over the past 10 years. Preferential attachment (or more commonly a hub-and-spoke model) is the tendency for nodes to establish relationships (or links) with nodes that have a high number of connections with other nodes. As a result, the connections demonstrate a power law distribution. The power law distribution is important because it illustrates that the network can be destroyed by eliminating the “hubs.”

Figures 6 and 7 in the appendix show the funding and data interdependencies by Service and FCB. As shown, the Navy appears to illustrate the greatest number of funding and data interdependencies. Interdependencies by FCB appear fairly mixed.

Future Activities

This paper provides a short description of some of the network characteristics of the funding and data interdependencies of major defense acquisition programs. Where the discussion focused on descriptions, recent advances allow the ability to test the structural descriptions on program performance. In exponential random graph models (ERGM), the ties serve as predictors of performance. ERGMs are capable of testing a host of structural arrangements for their influence on outcomes. Employing Markov Chain Monte Carlo Maximum Likelihood Estimation techniques, probabilities can be ascertained. Over the coming months, the structural nature of the interdependencies will be analyzed and evaluated for their influence on acquisition performance.

References

Ansoff, H. I. (1979). *Strategic management*. London, UK: The MacMillan Press.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

Comfort, L. (1994, September). Interorganizational learning following the Northridge earthquake of January 17, 1994. *Journal of Contingencies and Crisis Management*, *2*(3),174–188.

Cyert, R. M., & March, J. G. (1992). *A behavioral theory of the firm* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall. (Original work published 1963)

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, *17*, 109–122.

Hall, C. C., Ariss, L., & Todorov, A. (2007). The illusion of knowledge: When more information reduces accuracy and increases confidence. *Organizational Behavior and Human Decision Processes*, *103*, 277–290.

Herbert, S. (1969). *The sciences of the artificial* (1st ed.). Cambridge, MA: MIT Press.

Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997, October). A general theory of network governance: Exchange conditions and social mechanisms. *The Academy of Management Review*, *22*(4), 911–945.

Kauffmann, S. A. (1993). *The origins of order: Self-organization and selection in evolution*. New York, NY: Oxford University Press.

Lawrence, P. R., & Lorsch, J. W. (1967). Differentiation and integration in complex organizations. *Administrative Science Quarterly, 12*, 1–30.

Lawrence, P. R., & Lorsch, J. W. (1967). *Organization and environment: Managing differentiation and integration.* Cambridge, MA: Harvard University, Graduate School of Business Administration, Division of Research.

Levinthal, D. (1997). Adaptation on rugged landscapes. *Management Science, 43*(7), 934–950.

Levinthal, D., & Warglien, M. (1999). Landscape design: Designing for local action in complex worlds. *Organization Science*, *10*(3), 342–357.

March, J. G., & Simon, H. A. (1958). *Organizations*. New York, NY: Wiley.

McPherson, J. M., & Ranger-Moore, J. (1991). Evolution on a dancing landscape: Organizations and networks in dynamic blau space. *Social Forces*, *70*,19–42.

Miles, R. E., & Snow, C. C. (1978). *Organizational strategy, structure, and process.* New York, NY: McGraw-Hill.

Miles, R. E., & Snow, C. C. (1992, Summer). Causes of failure in network organizations. *California Management Review*.

Miles, R. E., Snow, C. C., & Pfeffer, J. (1974). Organization-environment: Concepts and issues. *Industrial Relations*, *13*, 244–264.

Milliken, F. (1987). Three types of perceived uncertainty about the environment: State, effect, and response uncertainty. *Academy of Management Review*, *12*(1), 133–143.

Perry-Smith, J. E., & Shalley, C. E. (2003). The social side of creativity: A static and dynamic social network perspective. *Academy of Management Review*, *28*(1), 89–106.

Simon, H. A. (1973). Applying information technology to organizational design. *Public Administration Review*, *33*(3), 268–278.

Simon, H. A. (1976). *Administrative behavior. A study of decision-making processes in administrative organization* (3rd ed.). London, UK: The Free Press.

Sosa, M. (2011). Where do creative interactions come from? The role of tie content and social networks. *Organization Science*, *22*(1),1–21.

Stacey, R. D. (2002). *Strategic management and organisational dynamics: The challenge of complexity* (3rd ed.). Harlow: Prentice Hall.

Thompson, J. D. (1967). *Organizations in action: Social science bases of administrative theory.* New York, NY: McGraw-Hill.

Turner, J. (1988). *A theory of social interaction*. Palo Alto, CA: Stanford University Press.

Volberda, H. W., Foss, N. J., & Lyles, M. A. (2010). Absorbing the concept of absorptive capacity: How to realize its potential in the organization field. *Organization Science, 21*, 931–951.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. New York, NY: Cambridge University Press.

Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *The American Journal of Sociology*, *87*(3), 548–577.

Acknowledgements

This material is based upon work supported by the Naval Postgraduate School Acquisition Research Program under Grant No. 00244-10-1-0068.

Appendix

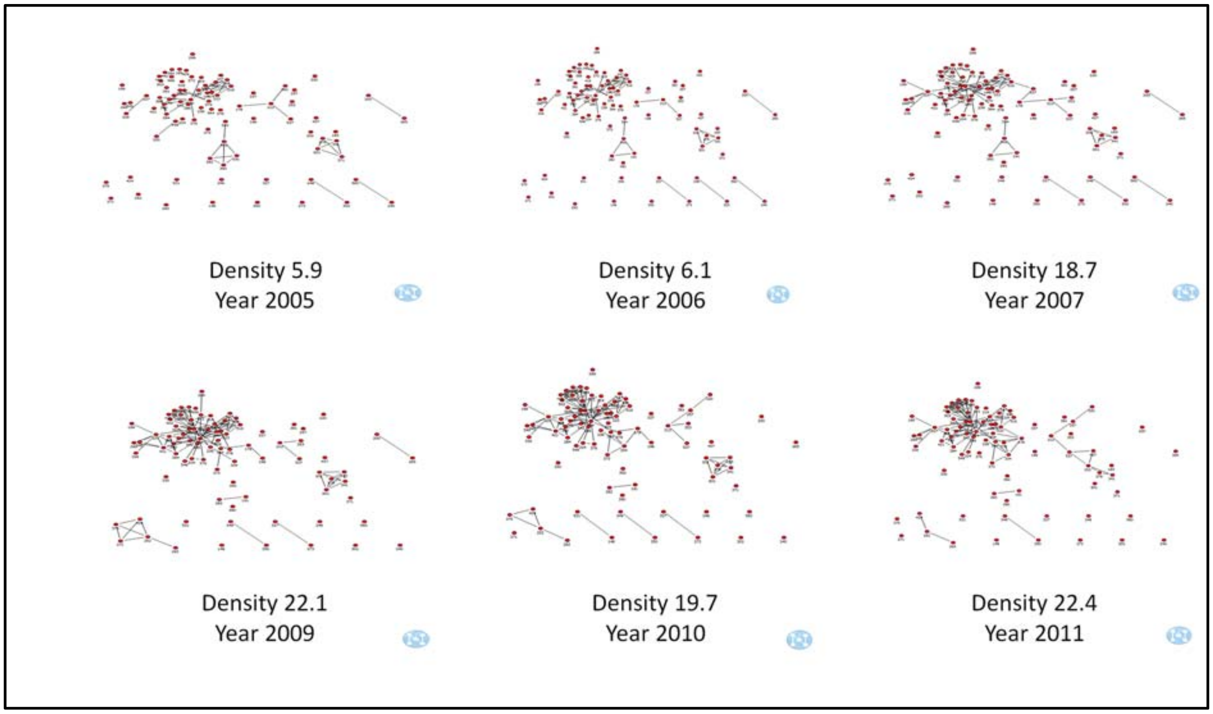


Figure 1. Funding Interdependencies

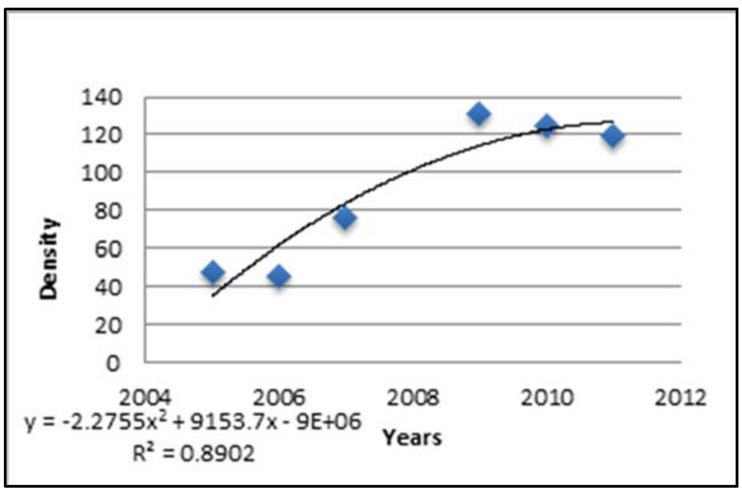


Figure 2. Funding Density Over Time

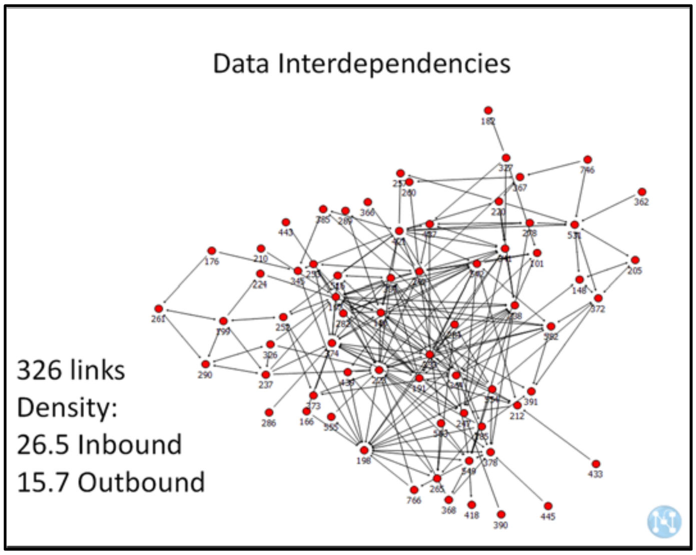


Figure 3. Data Interdependencies

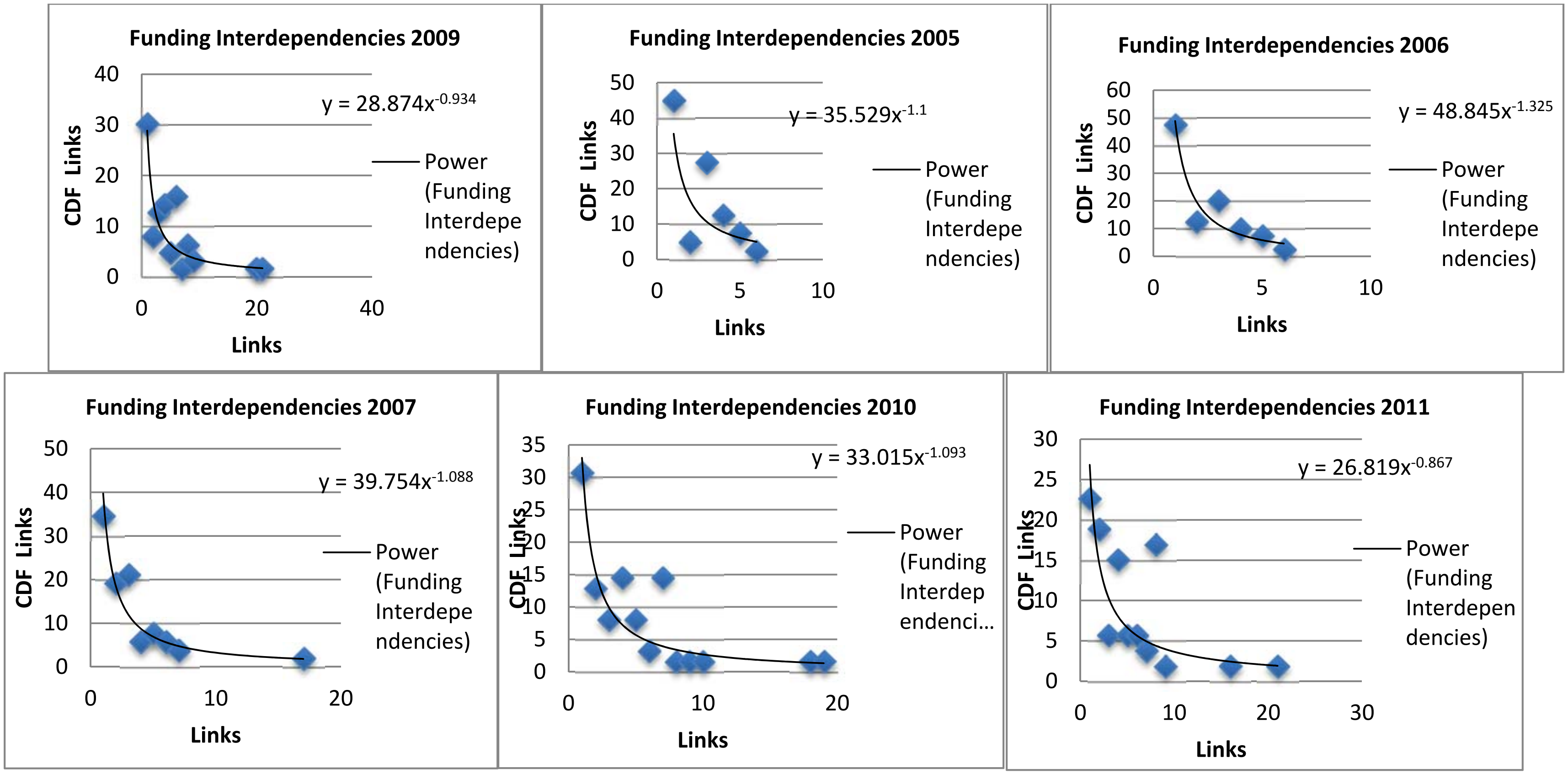


Figure 4. Preferential Attachment of Funding Interdependencies

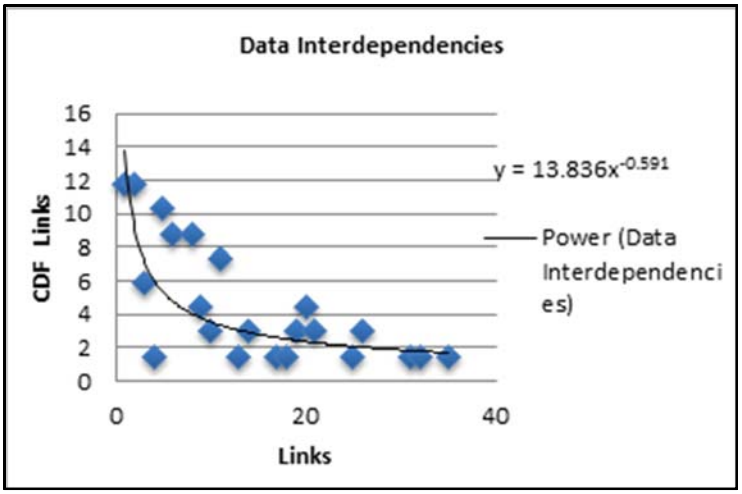


Figure 5. Preferential Attachment of Data Interdependencies

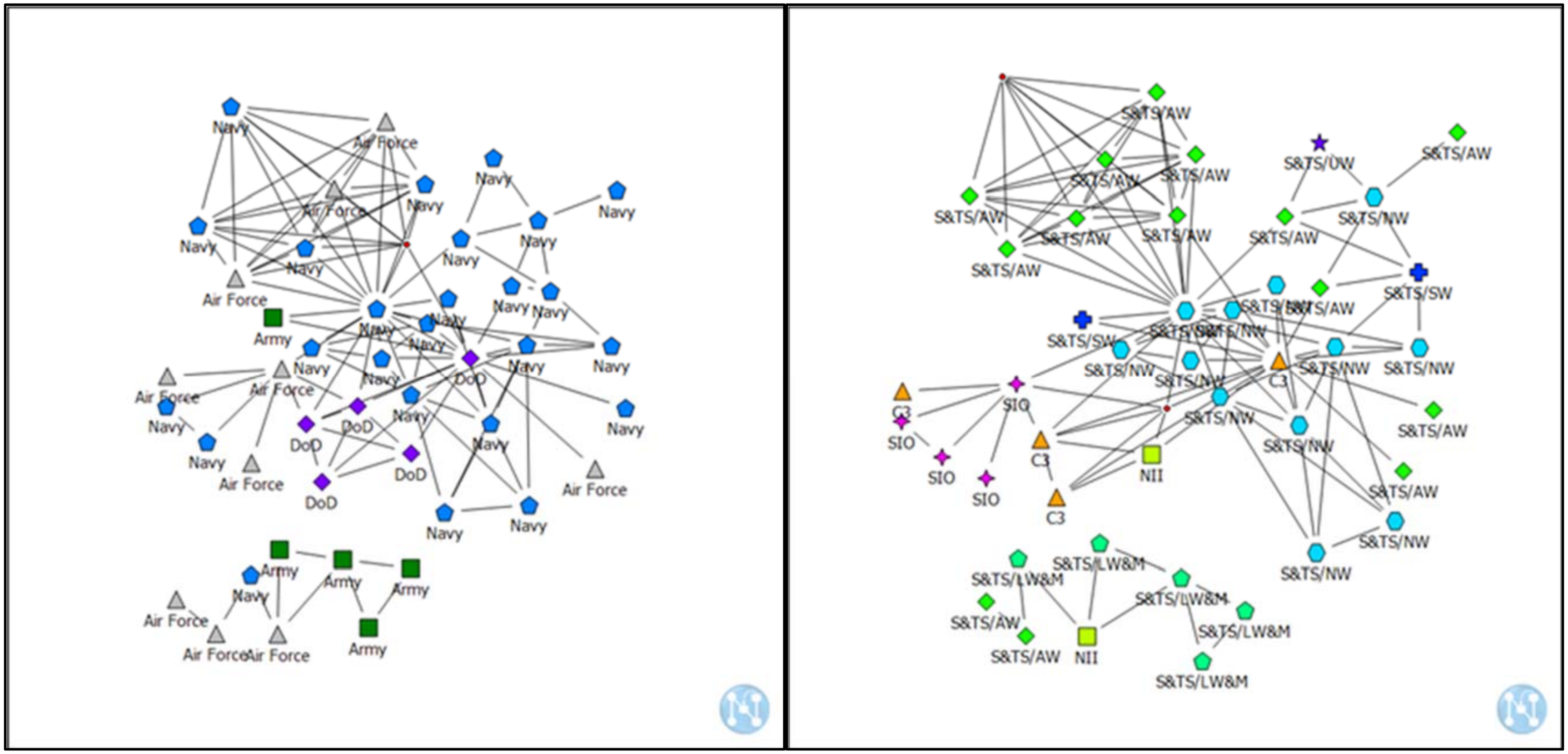


Figure 6. Funding Interdependencies by Service and FCB

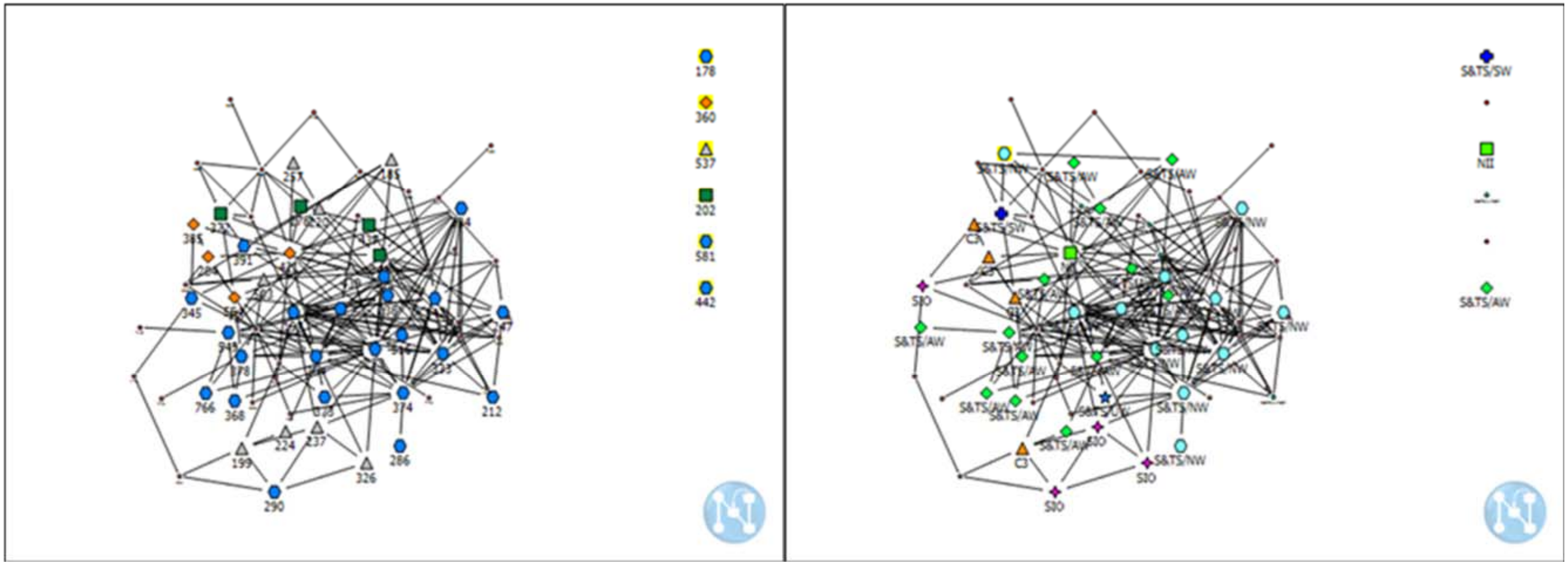


Figure 7. Data Interdependencies by Service and FCB

Table 1. Common Network Teams

Node: a person, team, organization, computer, etc., in a network
Tie: a connection between two nodes
Directed Network: a network where the tie is directional in nature
Undirected Network: a network where the ties are not directional
Ego: the subject of the discourse
Alter: the node that the ego has ties with
Ego Network: the network in light of a given ego
Dyad: two nodes linked into a pair. Networks can be decomposed into their dyads, or pairs.
Structuralist Paradigm: sees the network structure as the defining characteristic of an individual node's behavior. By extension, two nodes that share structurally similar characteristics will witness similar outcomes.
Connectionist Paradigm: The focus is on the resources that flow through the ties; the ties act as conduits for the flow of resources.
Diffusion: a measure of the spread of an innovation or characteristic throughout the network
Social Capital: The primary focus of the Connectionist paradigm is concerned with the resources that are gained (or lost) via the ties, and it views success as a function of these ties.
Structural Capital: The primary focus of the Structuralist paradigm is concerned with the position of nodes in a network and how this influences outcomes.
Centrality: the extent to which a given node(s) dominates the number of ties. When only a few nodes have a large number of ties compared to the others, the network is viewed as highly centralized.
Structural Equivalence: Actors (or nodes) are structurally equivalent to the extent that they are similar in their ties.
Relational Embeddedness: relates to the quality and depth of a single dyadic tie
Structural Embeddedness: relates to the extent to which a given node's alters are interconnected
Geodesic Distance: represents how far one node is from another. It is often represented as how near or far a node is from another.
Closure: Is a measure of the number of triads (or connections among three nodes) that exist in the network
Structural Hole: A hole in the network that a node could bridge and thus act as a go-between. In this way, structural holes can often control the two nodes that they connect.
Broker: Per the definition of *structural hole*, a broker spans two or more subnetworks.
Multiplex Ties: when a given node connects with another node in multiple networks. For example, a node may be connected to another node in both a funding network and a data-sharing network.

Homophily/Heterophily: indicates the extent to which one node is similar to another on key characteristics
Degree Distribution: the variance in the distribution of ties in a network
Network Connectivity: reflects the “size” of the network by the longest path from one node to another
Network Density: the proportion of ties in a network relative to the total number possible
Pattern of Clustering: refers to the absence or presence of subnetworks
Degree Assortativity: reflects the degree to which nodes with a similar number of ties connect with each other
Cohesion: the degree to which nodes are connected directly to each other. Under low cohesion, a number of cliques (or subnetworks) will be observed.
Bridge: a tie that is critical to the connectivity of the network. Elimination of the bridge is likely to result in a large number of factions.
Path Length: the length from one node to another. Typically measured in terms of how many nodes are in between the two.

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL
555 DYER ROAD, INGERSOLL HALL
MONTEREY, CA 93943

www.acquisitionresearch.net